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# Forest Health Protection Report

**Intermountain Region, State and Private Forestry**

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## Status of White Pine Blister Rust in Intermountain Region White Pines

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**Abstract**

Recent investigations have documented high levels of white pine blister rust (WPBR) in the whitebark pine and limber pine of the Rocky Mountain Region. However, in the Intermountain Region, little is known about the disease which occurs on whitebark, limber, western white, sugar, and potentially, bristlecone pines. We formally surveyed white pines at 100 sites, and collected incidental sample data at an additional 27 sites within the Intermountain Region. Objectives were to investigate WPBR incidence, intensity, damage, mortality and spread. Overall incidence of WPBR was 59% across the entire region, but varied substantially between national forests, and sample locations. Intensity within infected stands averaged 36% and ranged from 2% to 100%. Incidence and intensity appear to have increased dramatically in the northern portion of the Intermountain Region over the past 30 years, but the southward spread of the disease has slowed, and does not appear to be an immediate threat to Great Basin white pines. We found no evidence of a corridor of infected white pines between the Northern Rocky Mountains or Sierra Nevada and a satellite infection on the Lincoln National Forest in New Mexico. Smaller diameter trees suffered top kill and mortality more frequently than larger diameter trees. Only 34 of approximately 5000 trees inspected appeared to have died as a result of white pine blister rust infection, but mortality is expected to increase sharply in portions of the Intermountain Region as cankers from recent infections reach main tree stems.

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## Introduction

Most, if not all, white pines (genus *Pinus*, subgenus *strobus*) are susceptible to white pine blister rust disease (WPBR) caused by the introduced fungus *Cronartium ribicola* J. C. Fisch. *ex* Rabenh (Hoff et al. 1980, Keane and Arno 1993). *C. ribicola* causes only minimal damage to its primary *Ribes* spp. (ribes) host, but causes cankers that, in many cases, girdle and kill its alternate white pine host. Presence of the disease may also predispose the host to other pathogens, or destroy its reproductive potential by killing the uppermost, cone-bearing branches (Kulhavy 1977, Keane et al. 1994, Krebill and Hoff 1995).

Within 30 years of its 1910 introduction into Vancouver, British Columbia, the fungus had caused high tree mortality throughout most of the range of the mixed-conifer zone white pine species, western white pine (*Pinus monticola* Dougl.) and sugar pine (*P. lambertiana* Dougl.) (Mielke 1943). By 1960, it had spread throughout much of the range of a high-elevation (subalpine) white pine species, whitebark pine (*P. albicaulis* Engelm.), especially where its distribution coincides with that of sugar pine and western white pine (Hoff et al. 1994).

Recent studies have shown that the WPBR epidemic is now decimating subalpine white pines in the northern Rocky Mountains (Keane and Arno 1993, Keane and Morgan 1994, Kendall et al. 1996). In western Montana, for example, Keane et al. (1994) reported that 83% of a sample of 2,503 whitebark pines, was infected with WPBR. Estimates of whitebark pine mortality are as high as 90% for portions of the Selkirk Range in northern Idaho, and for the east side of Glacier National Park (Kendall and Arno 1990).

Little is known about the current distribution, incidence, and damage associated with WPBR in the Intermountain Region because no WPBR surveys have been conducted in over 30 years. It appears that the disease was present in limber (*P. flexilis* James) and whitebark pines in Idaho and Wyoming national forests by the late 1960's (Krebill 1964, Brown and Graham 1969). However, incidence of the disease appeared to be very low in Idaho and Wyoming during this time period. We are not aware of any previous reports of WPBR in the white pines of Nevada or Utah.

The preliminary results of a more recent study in Yellowstone and Grand Teton National Parks suggest that WPBR may be increasing in the whitebark and limber pines of that region (Kendall et al. 1996). The disease is also spreading into new areas. In 1990, WPBR was discovered in southwestern white pine (*Pinus strobiformis* Engelm.) in the Sacramento and adjoining White Mountains of New Mexico (Hawksworth 1990, Conklin 1994). The infected population of trees lies over 600 miles away from any other known WPBR infections. Forest

managers questioned whether the WPBR reached the New Mexico location via a corridor of infected pines and ribes, by very long-distance spore dispersal, or by the accidental introduction of infected nursery stock (Conklin 1994).

The possibility of intensification of WPBR to the north, and spread of the disease into distant, isolated areas such as New Mexico, but also southeastern Wyoming (Brown 1978), and South Dakota (Lundquist and Geils 1992), raised concerns that the disease could affect areas previously considered to be too isolated or too climatically unfavorable to infection by *C. ribicola*.

Thus, a disease survey was conducted in 1995-1997 to document WPBR infection characteristics (incidence, intensity, damage, and mortality) in the Intermountain Region, and to investigate whether WPBR has increased, intensified, or spread since the 1960's.

## Methods

We surveyed for WPBR at 100 locations during the summers of 1995 through 1997. In Idaho, central and eastern Nevada, and western Wyoming we inspected whitebark and limber pine stands. In Utah, where whitebark pine does not occur (Critchfield and Little 1966) we inspected limber pine and bristlecone pine (*P. longaeva* Engelm.) stands. In western Nevada and the portion of the Intermountain Region that extends into eastern California, we surveyed western white pine, as well as whitebark, limber, and bristlecone pines. Sugar pine occurs in the far western portion of the region, but the species was not present at any of our sample locations.

Some sample sites were located outside of national forest boundaries within Bureau of Land Management, National Park Service, or other ownerships. Data from these locations were combined with the data for the closest national forest.

We relied on information from local forest managers to locate accessible white pine stands to sample. The sampling design, therefore, was a survey of locations within the study area that could be reached within approximately 1/2 day of hiking from a road or backcountry camping location. In each white pine area, we sampled the first patch we encountered that appeared to have at least 50 white pines over 1.37 m (4.5 ft) tall.

During the 1995 field season 10 rectangular plots were installed according to the methods specified by the Whitebark Pine Monitoring Network (Kendall 1995). These variable length and width plots were sized so that at least 50 trees were included in the sample. For the 1996 and 1997 field seasons we installed 90 strip

transects to delineate sample trees. We switched to transects because white pine species in the Intermountain Region tend to grow as dispersed woodlands, or as infrequent seral componenets in subalpine forests; obtaining 50 white pines in a rectangular plot of a reasonable size was often not possible. Also, in areas where white pine grew in denser stands, using plots created a potential bias toward sampling in the densest stands where plots were more easily established. Once established in the stand both the rectangular plots and the strip transects precluded a biased tree selection by imposing bounds on which trees were inspected. Location criteria and data collection procedures were identical for plots and transects, so the data were combined for our analysis.

Strip transects were 15 feet wide and oriented along the contour of the slope or perpendicular to the contour from an arbitrary point on the edge of the stand. We traversed the transect until approximately 50 white pines, greater than 4.5 feet tall, (standing dead or alive, but at least 30 live or recently killed trees) had been sampled or until we reached the edge of the stand. If the edge of the stand was encountered before 50 trees had been inspected, the transect was offset 15 feet toward the center of the stand, and traversed back through the stand, parallel to the centerline of the previous transect. Sampling continued in this manner until approximately 50 total trees and at least 30 live trees had been inspected. Care was taken not to double sample trees which fell on the edge of adjacent transect strips.

Each white pine within the strip transect was visually inspected, using binoculars, for disease signs and symptoms and other non-disease related damage. DBH (diameter at breast height, 4.5 feet above the ground) was measured in 2 inch size classes. For trees infected with WPBR, the distance from the main stem to the closest (most proximal) branch canker, and the effect of this canker was recorded. Dead trees were categorized as either new dead or old dead. New dead trees had intact bark, fine limbs and/or needles still present on the tree. Old dead trees had either sloughing bark, or missing leaves and fine limbs.

An additional 27 transects were established where white pines were encountered en route to or from predetermined sample areas. Most of these "incidental" samples were located in lower timberline rather than subalpine white pine stands. We treat them separately because they were often located near roads or trails, and usually did not meet the sampling criterion of at least 50 trees. Sampling methods were identical to the methods described above, except that damage and mortality data were not collected. Since 11 of these samples contained less than 30 trees, and 8 of those had less than 15 trees, intensity estimates are probably less accurate than the transect and plot estimates. Nevertheless, data from these samples were deemed useful for describing the

geographic extent of WPBR throughout the study area and for generating hypotheses about the spread and intensification of the disease. We clearly distinguish how these supplemental data are used throughout the paper.

The definitions for incidence, intensity, and damage used in this paper are as follows: WPBR incidence is the number of infected sample locations (stands) divided by the total number of stands sampled. Intensity is the percentage of live trees in the stand that had a WPBR canker(s). Damage is based on the distance of the most proximal branch canker to the main stem or the effect of stem cankers (top kill, mortality). Mortality was calculated from diagnoses of new dead trees. Trees that had definite symptoms of WPBR infections (i.e. fusiform swellings, fungal periderm tissue, and broken, cracked bark girdling the tree) were presumed to have been killed by WPBR. We made no attempt to diagnose the cause of mortality in old dead trees.

## Survey Results

### *White Pine Blister Rust Incidence and Intensity*

Regionwide incidence of WPBR was 59% (59 of the 100 formally sampled stands). The average intensity in the infected stands was approximately 36%, and the average percent of sample stands infected was about 21%. The addition of the 27 incidental samples did not substantially change these overall infection values (Table 1).

In general, WPBR was most prevalent and intense in the Payette, Targhee, and Boise National Forests. The disease was found in all but one sample stand and intensity averaged about 50% in these forests. White pine blister rust was not observed on the Dixie, Humboldt, Uinta, and Wasatch-Cache National Forests, and occurred in moderate levels in the other forests listed in Table 1.

White pine blister rust incidence and intensity varied as widely within national forests as between them (Figures 2 and 3). For example, intensity in the Targhee National Forest ranged from 2% to 100% in infected stands with all but one sample having WPBR present. In the Sawtooth National Forest, where no formal samples were infected with WPBR, one incidental sample of 50 trees had 100% intensity.

**Table 1.** Incidence and intensity of white pine blister rust from formal and incidental survey data collected during 1995 through 1997 in Intermountain West white pines.

| | Formal Transect and Plot Samples[1] | | | | Transect, Plot and Incidental Samples[2] | | | |
|---|---|---|---|---|---|---|---|---|
| National Forest[3] | Stands Sampled N | Stands Infected % | Average Intensity[4] % | Average Percent Infection[5] % | Stands Sampled N | Stands Infected % | Average Intensity % | Average Percent Infection % |
| Boise | 4 | 100 | 41.7 | 41.7 | 4 | 100 | 41.7 | 41.7 |
| Bridger-Teton | 11 | 45.5 | 21.6 | 9.8 | 12 | 50.0 | 34.7 | 17.4 |
| Caibou | – | – | – | 0 | 3 | 33.3 | 78.1 | 26.0 |
| Challis | 10 | 60.0 | 6.8 | 4.1 | 10 | 60.0 | 6.8 | 4.1 |
| Dixie | 2 | 0 | – | 0 | 2 | 0 | – | 0 |
| Humboldt | 6 | 0 | – | 0 | 6 | 0 | – | 0 |
| Payette | 7 | 100 | 59.1 | 59.1 | 8 | 100 | 57.9 | 57.9 |
| Salmon | 19 | 68.4 | 18.4 | 12.6 | 19 | 68.4 | 18.4 | 12.6 |
| Sawtooth | 6 | 0 | – | 0 | 13 | 23.1 | 40.2 | 9.3 |
| Targhee | 21 | 95.2 | 51.7 | 49.2 | 30 | 96.7 | 56.4 | 54.5 |
| Toiyabe | 9 | 44.4 | 32.6 | 14.5 | 10 | 40.0 | 32.6 | 13.0 |
| Uinta | 1 | 0 | – | 0 | 1 | 0 | – | 0 |
| Wasatch-Cache | 4 | 0 | – | 0 | 9 | 0 | – | 0 |
| Totals | 100 | 59.0 | 36.1 | 21.3 | 127 | 58.3 | 41.7 | 24.3 |

[1]n=90 strip transects and 10 rectangular plots
[2]n=90 strip transects, 10 rectangular plots, and 27 incidental strip transects
[3]samples located outside National Forest boundaries included with closest National Forest
[4]mean percent of trees infected in infected samples
[5]mean percent of trees infected in all samples

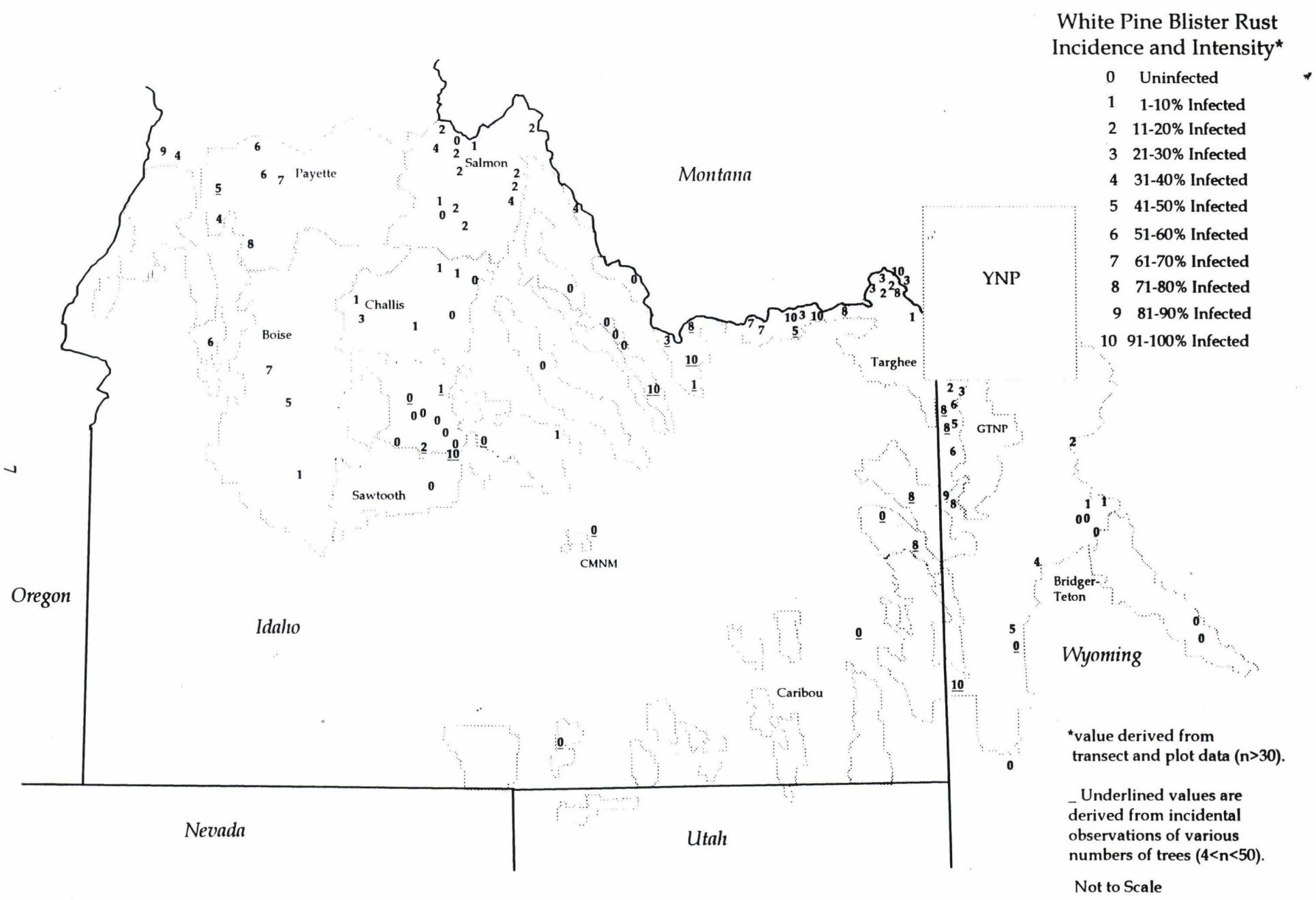


**Figure 1.** Percent of live white pines infected with white pine blister rust during 1995-1997 in the northern portion of the Intermountain Region

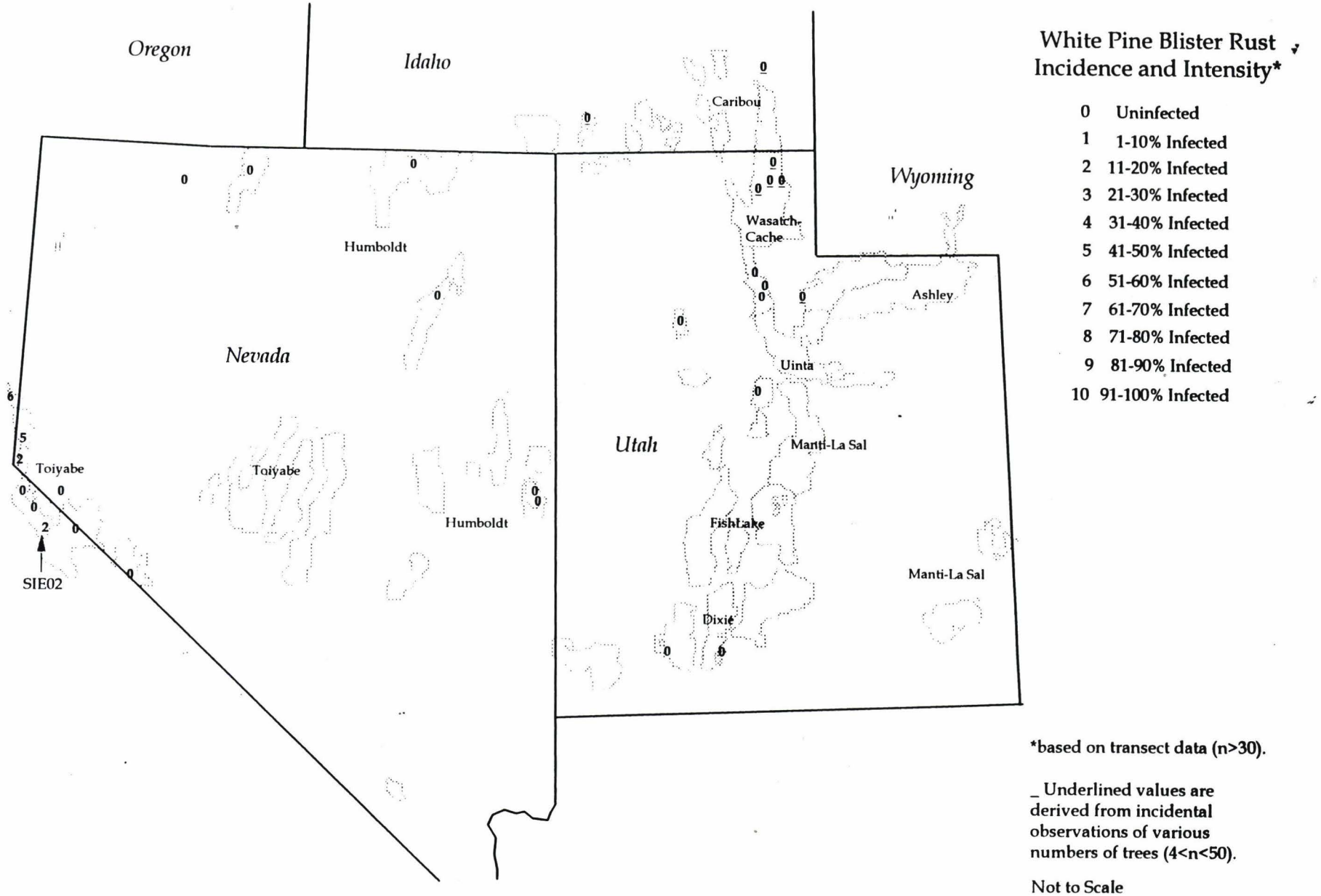


**Figure 2.** Percent of live white pines infected with white pine blister rust during 1995-1997 in the southern portion of the Intermountain Region

Potentially lethal infections were found in 61% (630 of 1029) of the WPBR-infected live trees (n=100 sample locations; damage data were not collected for the 27 incidental transects). Cankers within 6 inches of the main stem, or on the main stem, were considered potentially lethal. However, it should be noted that little is known about the inactivation rate and growth rate of cankers in most white pine species. Thus, infections far out on the end of a limb are also potentially lethal, and the number of these infections on each tree affects the probability of a single canker reaching the main stem (Slipp 1953). Average damage was similar between national forests (Figure 3), and as expected, damage varied with DBH class (Figure 4). Smaller diameter trees had a higher rate of severe infections, top kill, and mortality, while larger diameter trees had mostly minor infections.

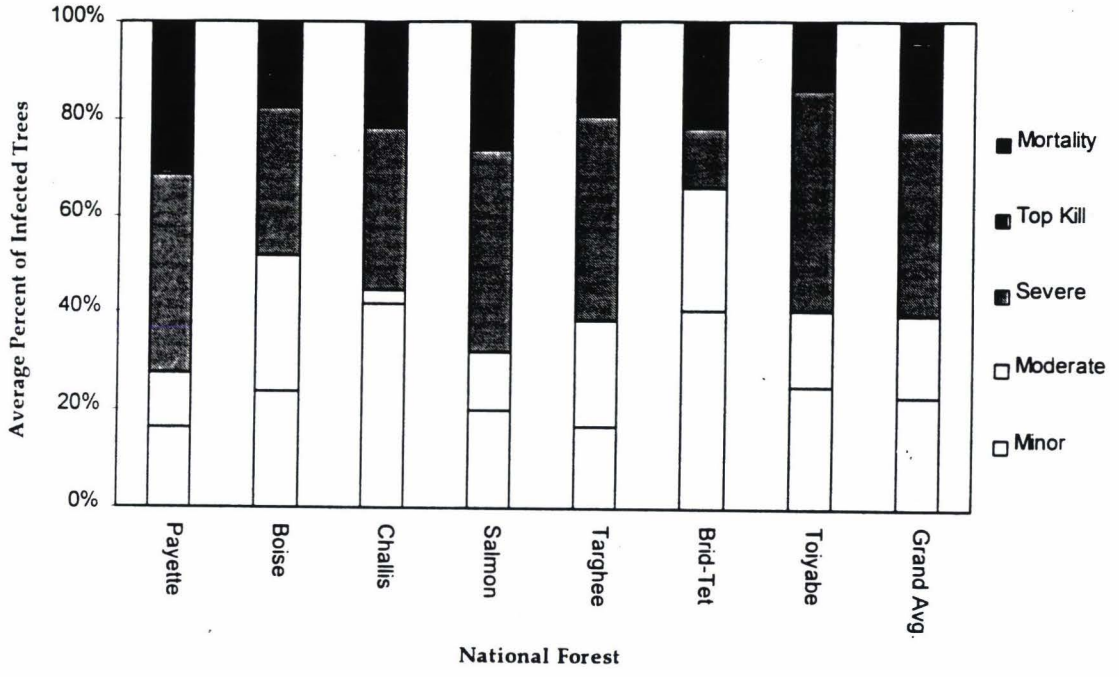


**Figure 3.** Damage caused by most proximal white pine blister rust canker in 1030 infected Intermountain Region white pines:
Minor = closest canker greater than 24 inches from the main stem.
Moderate = closest canker between 24 inches and 6 inches of the main stem.
Severe = closest canker within 6 inches or on the main stem.
Top Kill = canker has girdled the main stem, resulting in foliage death.
Dead = cambium completely girdled with no live foliage visible.

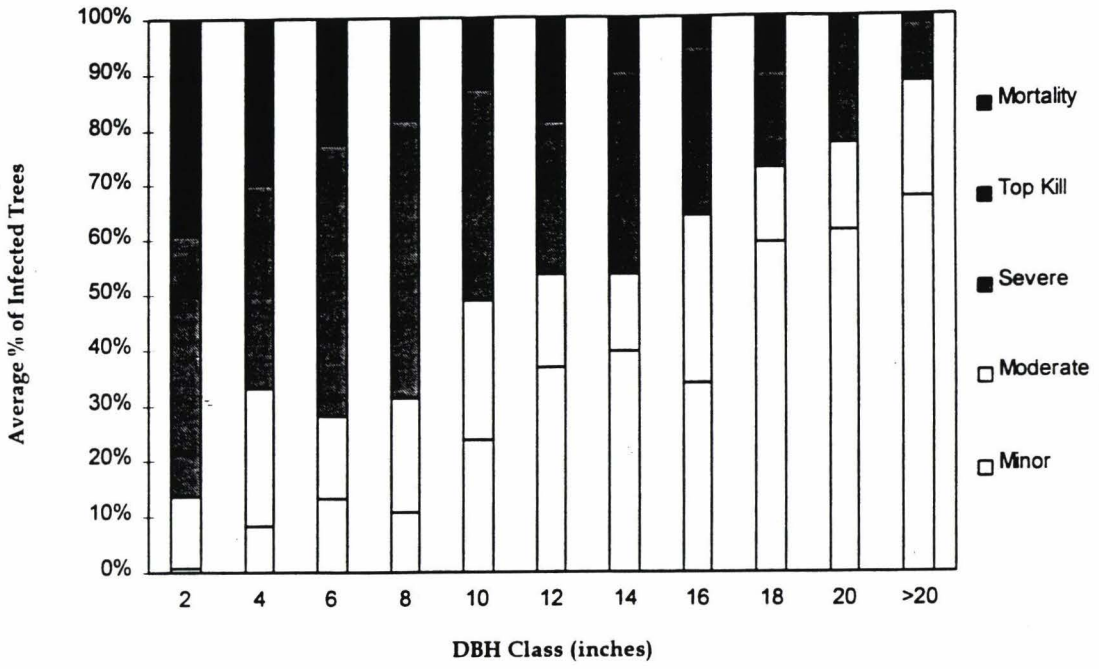


**Figure 4.** Damage caused by white pine blister rust in 1995-1997 in the Intermounatain Region (n=101 stands)

*Mortality Caused by White Pine Blister Rust*

Of the 5209 trees sampled in the 100 formal transects, 452 (9%) were standing dead trees, and 154 of these were categorized as new dead trees. The cause of death of the remaining 298 old dead trees could not be determined.

Of the new dead trees, 34 (22%) died from WPBR. The other 120 trees appeared to have died from factors such as physical damage, other diseases, and unknown causes. Twelve (35%) of the 34 trees were in the 2 inch DBH class, and all of the trees killed by WPBR were less than approximately 12 inches DBH. The overall mortality attributable to WPBR, calculated as these 34 trees divided by the total number of live and new dead trees, was 0.7%.

*White Pine Blister Rust Incidence and Intensity Compared to the 1967 Survey*

In 1967 a survey of Intermountain Region white pines was conducted by the U. S. D.A. Forest Service (Brown and Graham 1969). Only forests in the eastern portion of the region were sampled-the Targhee National Forest, Sawtooth National Forest, Bridger-Teton National Forest, Caribou National Forest, and Cache National Forest, now administered by the Caribou National Forest. Nine

of 31 sample locations that were inspected in 1967 had WPBR in either white pines or ribes. Since ribes plants were not the focus of our 1995-97 survey, we compared measures of infection in white pines only. We note, however, that ribes occurring in our 1995-1997 survey samples were examined, but no WPBR was observed in ribes during the study. From the data in the earlier report, we calculated an overall incidence of WPBR in pines to be about 12% (3 of 26 white pine sample locations), and an average intensity of approximately 38% (Table 2). We believe the rather high intensity for the 1967 survey may not be representive of overall intensity, because one small sample of 6 white pines was completely infected. The other 2 infected samples, which had 5% and 10% intensities, had sample sizes of 20 and 30 trees, respectively. Overall, slightly over 1% (14 of 1078) of the white pines they inspected had WPBR. In comparison, 31% (785 of 2546) of the white pines had WPBR in our survey of the same forests. Likewise, incidence of the disease in white pines, and the average percent infection were much higher in 1996 than in 1967 (see Table 2).

**Table 2.** Comparison of 1967 and 1995-1997 white pine blister rust survey results in four Idaho and Wyoming national forests.

| | 1995-1997 Survey[1] | | | | 1967 Survey[2] | | | |
|---|---|---|---|---|---|---|---|---|
| National Forest[3] | Stands Sampled N | Stands Infected % | Average Intensity[3] % | Average Percent Infection[4] % | Stands Sampled N | Stands Infected % | Average Intensity % | Average Percent Infection % |
| Bridger-Teton | 12 | 50.0 | 34.7 | 17.3 | 16 | 18.8 | 38.3 | 7.2 |
| Caibou | 3 | 33.3 | 78.1 | 26.0 | 4 | 0 | – | 0 |
| Sawtooth | 13 | 23.1 | 40.2 | 9.3 | 5 | 0 | – | 0 |
| Targhee | 30 | 96.7 | 56.4 | 54.5 | 1 | 0 | – | 0 |
| Totals | 58 | 67.2 | 52.4 | 35.2 | 26 | 11.5 | 38.3 | 4.4 |

[1]includes incidental observations
[2]summarized from Brown and Graham (1969)
[3]mean percent of trees infected in infected samples only
[4]mean percent of trees infected in all samples

### *Spread of White Pine Blister Rust in Wyoming National Forests*

The most southerly location of the disease in western Wyoming that we found was at 29 degrees N. latitude in the Gannett Hills near the Idaho border (LIM18). The 4 limber pines that we inspected at this lower timberline location had numerous WPBR cankers. The site, which is at the entrance to Allred Flat campground, is only about 28 miles farther south of the southern WPBR limit

reported by Brown and Graham (1969). The disease may be further south, however, because our only sample location south of the Allred site was over 25 air miles away on Commissary Ridge in the southernmost stand of whitebark pine in western Wyoming (R. Lanner, Pers. Com.). We found no WPBR at this location.

*Southward Spread of White Pine Blister Rust in Southern Idaho and Utah National Forests*

We found no WPBR south of Skinner Canyon (approximately 42 1/2° N Latitude on the Cache N. F.), the southernmost location in Idaho reported by Krebill (1964). However, we saw 2 limber pines on a hillside approximately 23 miles north of the Utah border near Montpelier, Idaho (Telephone Draw, Caribou National Forest) that, from a distance, appeared to have symptoms of WPBR infection. However, we were unable to reach the trees for closer inspection because of rugged terrain and time constraints. These trees are at a latitude approximately 10 miles farther south than the Skinner Canyon and Allred Campground sites. We found no evidence of WPBR infection in any of the limber pines we inspected farther south in the Caribou National Forest, or at any of our Utah sample locations.

*Spread of White Pine Blister Rust in Nevada and eastern California National Forests*

WPBR was not found in any of our samples of forest "islands" associated with the basin and range geomorphology that occurs throughout most of Nevada. However, WPBR was found in western white pine and whitebark pine at two locations in the Carson Range on the Toiyabe National Forest (CAR01 and CAR02). This is, to our knowledge, the first report of WPBR in Nevada. The Carson Range is not typical of the isolated forests elsewhere in the state, because it is linked by nearly continuous forest cover to the Sierra Nevada ecosystem.

WPBR has been present in sugar pine in the southern Sierra Nevada since at least the 1960's, and now extends throughout almost the entire range of that species (Kliejunas 1996). Southward spread of WPBR in western white pine and whitebark pine has been somewhat slower. The southernmost location of WPBR in whitebark and western white pine that we observed was in the Sierra Nevada at Ebbetts Pass (SIE02) at about 38 1/2 degrees N. latitude (see Figure 1). We know of no other reports of WPBR in whitebark pine south of this location in the Sierra Nevada. However, WPBR has been observed as far south as the Sequoia National Forest in recent years (J. Pronos, Pers. Comm.). We did not find WPBR in the whitebark and western white pines at our Carson-Iceburg Wilderness sample site (SIE01), which was our southernmost sample location in the Sierra

Nevada at a latitude approximately four miles south of Ebbetts Pass. We also did not observe the disease during informal inspections of 20 whitebark pines near Mammoth Lakes, California or 30 limber pines along the North Fork of Big Pine Creek, near the town of Big Pine, California (Smith, personal observation). Both of these locations are farther south than Tioga Pass, in Yosemite National Park where Hoff et al. (1994) reported that no WPBR was observed in whitebark pine in 1992.

## Discussion

The southward spread of WPBR in Idaho and Wyoming appears to have proceded very slowly since the 1960's. Furthermore, we found no evidence of WPBR in any of the isolated Great Basin forests, even those that are only a few miles from moderately high infection centers in the Sierra Nevada. For example, we did not find the disease in the Virginia Range (VIR01) or the Pine Nut Mountains (PNM01) which are within approximately 15 miles of infected stands in the Carson Range. Immediate spread of the disease into even more isolated white pine stands of Nevada and Utah appears unlikely at this time, but it cannot be ruled out.

The apparent absence of WPBR in Great Basin forests of Nevada and the western Rocky Mountain forests of Utah suggests that there is not a continuous, or even broken corridor of infected pines between the infection centers of the Sierra Nevada or Northern Rocky Mountain forests and the New Mexico infection site described by Hawksworth (1990). However, we did not investigate the possibility of a corridor of infected pines along any of the eastern Rocky Mountain ranges. These Colorado mountain ranges lie south of a known infection center in the Medicine Bow National Forest in southeastern Wyoming (Brown 1978), but we are unaware of any reports of WPBR in Colorado.

Although the geographic extent of WPBR appears to have changed little in the past 30 years, incidence and intensity of WPBR have increased sharply within infected portions of the region. Barring unanticipated high canker inactivation rates, this higher intensity will result in an increase in white pine top kill and mortality in the coming decades.

That small diameter (and usually younger) white pines tend to suffer more serious damage, also does not bode well for the future of white pines in the region. The DBH-damage class relationship is probably a result of the distance between the foliage (the point of infection) and the main stem, and the amount of cambium circumference that must be girdled in order to kill the top of the tree or cause mortality.

In some heavily-infected stands most, if not all of the smaller trees are infected. It is difficult to say with certainty whether any of these trees will live long enough to reproduce because estimates of canker growth rates and natural inactivation of cankers are derived from lower-elevation western white and sugar pine studies (Harvey 1967, Kimmey 1969, Hungerford 1977). However, It is likely that only trees with genetic resistance to WPBR will be able to survive to maturity in these high-intensity areas without human intervention. Unfortunately, research has shown that resistant white pines are uncommon in nature (Hoff *et al.* 1980).

The long-term outlook is unclear. The increase in WPBR incidence and intensity since the 1960's surveys, suggests that the northern Intermountain Region's cool, dry conditions, which are not optimal for *Cronartium ribicola*, do not preclude WPBR infection or intensification. However, it is possible that the combination of an even more unfavorable climate and extreme isolation in the Great Basin forests, may prevent the fungus from invading or thriving there.

The area of immediate concern lies in the northern portion of the Intermountain Region where incidence is high, intensity is high on many sites, and mortality is beginning to occur. Increased mortality in the western and southern portions of the Greater Yellowstone ecosystem (GYE), on the Targhee and Bridger-Teton National Forests, is of particular concern. This area is home to the endangered grizzly bear (*Ursus arctos horribilis*) that uses whitebark pine seeds as an autumn food source. The abundance of whitebark pine seeds is linked to grizzly bear cub production and to the frequency of bear-human conflicts (Kendall and Arno 1990, Mattson and Reinhart 1994). Loss of this important food source may adversely affect grizzly bears outside of the GYE as well. For example, we found very high WPBR levels in the Centennial Mountains on the Idaho-Montana border, where whitebark pine populations are small and disjunct, and therefore vulnerable to extinction by this disease. This mountain range may become a corridor for grizzly bear movement between the GYE and the Bitterroot Range, a proposed grizzly bear reintroduction site.

Another problem area is the northwestern portion of the Intermountain Region (Payette National Forest). We observed extensive areas of mortality of whitebark pine in this region, but could not attribute the mortality to WPBR. We did find evidence of mountain pine beetle (*Dendroctonus ponderosae*) and root pathogens (unidentified) at several locations. The interaction of these opportunistic parasites and WPBR may accelerate white pine mortality in this area.

Additional research on the interaction of WPBR with other pathogens and damaging insects, climate, and site conditions is needed to determine where the

disease is likely to occur and be most damaging. Management actions that could be taken in areas already heavily infected include silvicultural and prescribed fire treatments to promote white pine reproduction, identifying resistant trees to increase genetic stock for resistance breeding programs, and possibly pruning infected limbs in some high value recreational sites where intensity is very low.

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**Appendix** Location of sample transects, and white pine blister rust incidence, intensity, and mortality

(WBP=Whitebark Pine, LP=Limber Pine, BCP=Bristlecone Pine, WWP=Western White Pine)

| National Forest and Sample ID | Species Sampled | Live Trees Sampled N | Live Trees Infected N | Live Trees Infected % | WPBR Mortality % | Coordinates Latitude | Coordinates Longitude | Sample Location |
|---|---|---|---|---|---|---|---|---|
| Boise | | | | | | | | |
| BOI01 | WBP | 39 | 3 | 7.7 | 0 | 43.61235 | 115.44104 | Near Trinity Mountain |
| BOI02 | WBP | 49 | 20 | 40.8 | 2.0 | 43.99066 | 115.32479 | N. of Shephard Peak |
| BOI03 | WBP | 47 | 30 | 63.8 | 1.9 | 44.17672 | 115.75901 | E. of Scott Mtn. Lookout |
| BOI04 | WBP | 57 | 31 | 54.4 | 0 | 44.41286 | 116.12706 | Snowbank Mountain |
| Bridger-Teton | | | | | | | | |
| BRI01 | WBP | 48 | 17 | 35.4 | 0 | 43.16663 | 110.18464 | Spring Creek near The Rim |
| BRI02 | WBP | 52 | 0 | 0 | 0 | 43.39252 | 110.08593 | Bacon Ridge, W. of Mosquito Lake |
| BRI03 | WBP | 50 | 3 | 6.0 | 0 | 43.46214 | 109.93764 | Near Fish Creek Work Center |
| BRI04 | WBP | 50 | 9 | 18.0 | 0 | 43.75610 | 110.07015 | Togwotee Pass |
| BRI05 | WBP | 51 | 22 | 43.1 | 0 | 42.84406 | 110.58272 | McDougal Gap |
| BRI06 | WBP | 53 | 0 | 0 | 0 | 42.07242 | 110.57198 | Commissary Ridge (BLM) |
| GRO01 | WBP | 53 | 3 | 5.7 | 0 | 43.44329 | 110.06318 | Buffalo Meadow |
| WIN01 | WBP | 51 | 0 | 0 | 0 | 42.69115 | 109.23433 | Upper S. Temple Creek |
| WIN02 | WBP | 53 | 0 | 0 | 0 | 42.67272 | 109.25683 | Big Sandy Opening |
| WIN03 | WBP | 37 | 0 | 0 | 0 | 43.45941 | 109.94090 | Near Fish Creek |
| WIN04 | WBP | 39 | 0 | 0 | 0 | 43.29536 | 109.93423 | Near Gypsum Creek |
| LIM18 | LP | 4 | 4 | 100 | — | 37.56362 | 112.84558 | Allred Flat |
| Caribou | | | | | | | | |
| LIM05 | LP | 15 | 0 | 0 | — | 43.36980 | 111.49372 | Fall Creek |
| LIM11 | LP | 30 | 0 | 0 | — | 42.65791 | 111.62572 | Soda Springs |
| LIM12 | LP | 32 | 25 | 78.1 | — | 43.20678 | 111.21272 | Jensen Pass |
| Dixie | | | | | | | | |
| CED01 | BCP/LP | 50 | 0 | 0 | 0 | 37.56362 | 112.84558 | Cedar Canyon |
| BRY01 | BCP/LP | 38 | 0 | 0 | 0 | 37.78900 | 112.14900 | Church Garden (NPS) |
| Humboldt-Toiyabe | | | | | | | | |
| HUM01 | WBP | 38 | 0 | 0 | 0 | 41.83000 | 115.46200 | Jarbidge Mountain |
| PFR01 | LP/WBP | 50 | 0 | 0 | 0 | 41.68096 | 118.74585 | Pine Forest Range (BLM) |

| National Forest and Sample ID | Species Sampled | Live Trees Sampled N | Live Trees Infected N | Live Trees Infected % | WPBR Mortality % | Coordinates Latitude | Coordinates Longitude | Sample Location |
|---|---|---|---|---|---|---|---|---|
| SAN01 | LP | 47 | 0 | 0 | 0 | 41.78800 | 117.55075 | Santa Rosa Mtns. |
| RUB01 | WBP/LP | 36 | 0 | 0 | 0 | 40.63174 | 115.40645 | Ruby Mtns. |
| SNA01 | LP | 41 | 0 | 0 | 0 | 39.00517 | 114.30749 | Wheeler Peak (NPS) |
| SNA02 | LP | 34 | 0 | 0 | 0 | 38.96481 | 114.27636 | Baker Creek (NPS) |
| CAR01 | WBP | 49 | 24 | 49.0 | 0 | 39.31264 | 119.89728 | Mt. Rose Summit |
| CAR02 | WWP | 50 | 6 | 12.0 | 0 | 39.06936 | 119.89367 | Spooner Summit |
| SIE01 | WBP/WWP | 49 | 0 | 0 | 0 | 38.51056 | 119.56856 | Carson-Iceburg Wilderness |
| SIE02 | WBP/WWP | 45 | 7 | 15.6 | 0 | 38.54268 | 119.81133 | Ebbetts Pass |
| SIE03 | WWP | 50 | 0 | 0 | 0 | 38.67728 | 119.59634 | Monitor Pass |
| PNM01 | WWP | 51 | 0 | 0 | 0 | 38.81221 | 119.51499 | Pine Nut Mountains (BLM) |
| BAL01 | WWP | 50 | 27 | 54.0 | 0 | 39.60208 | 120.10436 | Bald Mtn. Range |
| SWE01 | WBP | 52 | 0 | 0 | 0 | 38.41627 | 119.26680 | Sweetwater Range |
| WHI01 | BCP | 47 | 0 | 0 | 0 | 37.39044 | 118.17978 | Schullman Grove |
| VIR01 | WWP | 6 | 0 | 0 | — | 39.33252 | 119.63949 | Virginia Range (BLM) |
| Payette | | | | | | | | |
| SAL15 | WBP | 51 | 27 | 52.9 | 0 | 45.37411 | 115.86560 | Marshall Lake |
| SAL16 | WBP | 50 | 30 | 60.0 | 2.0 | 45.34305 | 115.84562 | Near California Lake |
| SAL17 | WBP | 46 | 30 | 65.2 | 0 | 45.31940 | 115.79160 | War Eagle Peak |
| SAL18 | WBP | 44 | 35 | 79.5 | 0 | 44.87426 | 115.94709 | Boulder Peak |
| SAL19 | WBP | 15 | 5 | 33.3 | 0 | 45.01326 | 116.11976 | Brundage Mountain |
| SEV01a | WBP | 45 | 38 | 84.4 | 0 | 45.35110 | 116.50976 | Seven Devils |
| SEV02a | WBP | 42 | 16 | 38.1 | 16.0 | 45.34903 | 116.49246 | Heaven's Gate |
| WBP04 | WBP | 50 | 25 | 50.0 | — | 45.18590 | 116.13010 | Hazard Lake |
| Salmon-Challis | | | | | | | | |
| BIT01 | WBP | 49 | 1 | 2.0 | 0 | 45.46384 | 114.32236 | Continental Divide-Spring Creek |
| BIT02 | WBP | 48 | 0 | 0 | 2.0 | 45.47249 | 114.35710 | Blue Nose Lookout |
| BIT03 | WBP | 50 | 7 | 14.0 | 3.8 | 45.55438 | 114.51407 | East of Reynolds Lake |
| BIT04 | WBP | 48 | 7 | 14.6 | 0 | 45.51721 | 119.83699 | Morgan Mountain |
| BIT05 | WBP | 51 | 0 | 0 | 0 | 44.78314 | 113.35547 | Grizzly Hill |
| BIT06 | WBP | 52 | 21 | 40.4 | 0 | 45.08084 | 113.54208 | Headwaters of Kenney Creek |

| National Forest and Sample ID | Species Sampled | Live Trees Sampled N | Live Trees Infected N | Live Trees Infected % | WPBR Mortality % | Coordinates Latitude | Coordinates Longitude | Sample Location |
|---|---|---|---|---|---|---|---|---|
| CLE01 | WBP | 47 | 15 | 31.9 | 4.1 | 45.39577 | 114.61340 | Corn Lake |
| CLE02 | WBP | 52 | 10 | 19.2 | 0 | 45.38938 | 114.55931 | Long Tom Ridge/Swamp Creek |
| CLE03 | WBP | 50 | 10 | 20.0 | 1.9 | 45.35919 | 114.57914 | Long Tom Ridge/Bear Camp Spring |
| LEM02 | WBP | 44 | 0 | 0 | 0 | 44.43026 | 113.32289 | W. of Meadow Lake Campground |
| LEM03 | WBP | 49 | 0 | 0 | 0 | 44.44096 | 113.31661 | N. of Meadow Lake Campground |
| LEM04 | WBP | 31 | 0 | 0 | 0 | 44.65323 | 113.65154 | Mill Lake |
| SAL01 | WBP | 49 | 6 | 12.2 | 0 | 45.25773 | 114.01104 | Salmon R. Mountain/Wallace Lk. |
| SAL02 | WBP | 48 | 8 | 16.7 | 0 | 45.19917 | 114.04678 | Salmon R. Mountain/Turner Gulch |
| SAL03 | WBP | 53 | 21 | 39.6 | 0 | 45.13484 | 114.06392 | Salmon R. Mountain/Phelan Mtn. |
| SAL04 | WBP | 51 | 6 | 11.8 | 0 | 45.00075 | 114.42997 | Red Rock Peak |
| SAL05 | WBP | 52 | 6 | 11.5 | 0 | 45.06037 | 114.44690 | Quartzite Mountain |
| SAL06 | WBP | 52 | 3 | 5.8 | 0 | 45.09697 | 114.51502 | Crags Campground |
| SAL07 | WBP | 50 | 0 | 0 | 0 | 45.08478 | 114.52858 | South of Crags Campground |
| LOS01 | LP | 31 | 0 | 0 | 0 | 44.13672 | 113.81795 | W. Slope, Mt. Borah |
| BOU01 | WBP | 42 | 0 | 0 | 0 | 43.91627 | 114.36801 | North Fork of Lost River Hdwtrs. |
| MAC01 | WBP | 52 | 1 | 1.9 | 0 | 43.88511 | 113.68992 | White Knob Mtns. |
| SAL08 | WBP | 51 | 1 | 2.0 | 0 | 44.46408 | 114.73555 | Loon Creek Summit |
| SAL09 | WBP | 52 | 0 | 0 | 0 | 44.47163 | 114.48829 | Mill Creek Summit |
| SAL10 | WBP | 34 | 2 | 5.9 | 0 | 44.75359 | 114.67964 | Sleeping Deer Lookout |
| SAL11 | WBP | 52 | 1 | 1.9 | 0 | 44.67445 | 114.55989 | Fly Creek Point |
| SAL12 | WBP | 52 | 0 | 0 | 0 | 44.60336 | 114.47234 | Twin Peaks |
| SAL13 | WBP | 52 | 4 | 7.7 | 0 | 44.58764 | 115.00826 | Sheep Mountain |
| SAL14 | WBP | 47 | 10 | 21.3 | 2.1 | 44.56863 | 115.01072 | Fontez Creek |
| Sawtooth | | | | | | | | |
| SAW01 | WBP | 71 | 0 | 0 | 0 | 43.96262 | 114.69275 | Pole Creek |
| SAW02 | WBP | 62 | 0 | 0 | 0 | 43.88052 | 114.71073 | Galena Summit |
| SAW03 | WBP | 49 | 0 | 0 | 0 | 43.59235 | 114.68143 | Dollarhide Summit |
| SAW04 | WBP | 52 | 0 | 0 | 0 | 44.02695 | 114.65040 | Phyllis Lake |
| SAW05 | WBP | 89 | 0 | 0 | 0 | 43.81082 | 114.80664 | Frenchman Creek |
| SAW06 | WBP | 46 | 0 | 0 | 0 | 43.84080 | 114.50401 | Boulder City |

| National Forest and Sample ID | Species Sampled | Live Trees Sampled N | Live Trees Infected N | Live Trees Infected % | WPBR Mortality % | Coordinates Latitude | Coordinates Longitude | Sample Location |
|---|---|---|---|---|---|---|---|---|
| WBP01 | WBP | 30 | 5 | 16.7 | — | 43.32808 | 114.61948 | Boulder View |
| WBP02 | WBP | 50 | 2 | 4.0 | — | 44.17230 | 114.57488 | Railroad Ridge |
| WBP03 | WBP | 20 | 0 | 0 | — | 43.85551 | 114.88476 | Beaver Creek |
| LIM01 | LP | 15 | 0 | 0 | — | 43.82085 | 114.25056 | Trail Creek |
| LIM03 | LP | 50 | 50 | 100 | — | 43.80094 | 114.41991 | Murdock Creek |
| LIM02 | LP | 50 | 0 | 0 | — | 43.42440 | 113.54859 | Craters of the Moon (NPS) |
| LIM19 | LP | 50 | 0 | 0 | — | 42.31617 | 113.64109 | Mt. Harrison |
| Targhee | | | | | | | | |
| CEN01 | WBP | 48 | 32 | 66.7 | 4.0 | 44.41939 | 112.34467 | Pleasant Creek Summit, W. |
| CEN02 | WBP | 51 | 33 | 64.7 | 0 | 44.41944 | 112.34460 | Pleasant Creek Summit, E. |
| CEN03 | WBP | 38 | 8 | 21.1 | 0 | 44.55312 | 111.42022 | Sawtelle Creek |
| CEN04 | WBP | 42 | 5 | 11.9 | 0 | 44.56013 | 111.44394 | Sawtelle Krumholtz site |
| CEN05 | WBP | 49 | 45 | 91.8 | 2.0 | 44.53543 | 112.05843 | Big Table Mountain, W. |
| CEN06 | WBP | 48 | 45 | 93.8 | 0 | 44.53213 | 112.03794 | Big Table Mountain, E. |
| CEN07 | WBP | 33 | 10 | 30.3 | 0 | 44.41944 | 112.34460 | Sawtelle Peak |
| CEN08 | WBP | 41 | 33 | 80.5 | 2.3 | 44.56038 | 111.58557 | Blair Lake |
| CEN09 | WBP | 50 | 11 | 22.0 | 0 | 44.53138 | 111.85361 | Hancock Lake |
| HEN01 | WBP | 33 | 32 | 97.0 | 15.2 | 44.68883 | 111.29229 | Targhee Pass/Avalanche Gulch |
| HEN02 | WBP | 42 | 31 | 73.8 | 6.0 | 44.62466 | 111.25966 | Mt. Two Top |
| HEN03 | WBP | 52 | 11 | 21.2 | 0 | 44.69912 | 111.39685 | Black Mountain |
| LEM01 | WBP | 42 | 0 | 0 | 0 | 44.34804 | 113.26162 | Spring Mountain Canyon |
| MCP01 | WBP | 52 | 1 | 1.9 | 0 | 44.51267 | 111.15442 | Moose Crk. Plateau/Black Canyon |
| TET01 | WBP | 52 | 9 | 17.3 | 0 | 44.11943 | 110.89848 | Flagg Ranch Road |
| TET02 | WBP | 46 | 34 | 73.9 | 2.1 | 43.49712 | 110.95485 | Teton Pass-East |
| TET03 | WBP/LP | 49 | 20 | 40.8 | 0 | 43.88905 | 110.96675 | Badger Creek |
| TET04 | LP | 49 | 43 | 87.8 | 0 | 43.49131 | 110.95602 | Teton Pass-West |
| TET05 | WBP | 48 | 26 | 54.2 | 0 | 43.78479 | 110.93210 | Targhee Ski Resort |
| TET06 | WBP | 53 | 16 | 30.2 | 0 | 44.12063 | 110.85708 | Camp Loll |
| TET07 | WBP | 51 | 27 | 52.9 | 1.9 | 44.03884 | 110.90426 | Hominy Peak |
| WBP05 | WBP | 9 | 7 | 77.8 | — | 44.04221 | 110.94600 | Hominy Peak, W. |

| National Forest and Sample ID | Species Sampled | Live Trees Sampled N | Live Trees Infected N | Live Trees Infected % | WPBR Mortality % | Coordinates Latitude | Coordinates Longitude | Sample Location |
|---|---|---|---|---|---|---|---|---|
| WBP06 | WBP | 40 | 20 | 50.0 | — | 44.51400 | 111.86200 | Alduous Lake |
| WBP07 | WBP | 10 | 8 | 80.0 | — | 44.07353 | 110.97240 | Jackass Loop |
| LIM04 | LP | 50 | 40 | 80.0 | — | 44.37300 | 112.70800 | Webber Creek |
| LIM06 | LP | 30 | 24 | 80.0 | — | 43.52364 | 111.25986 | Mike Spencer Canyon |
| LIM07 | LP | 15 | 4 | 26.7 | — | 44.27560 | 112.75000 | Crooked Creek |
| LIM08 | LP | 50 | 4 | 8.0 | — | 44.30068 | 112.92534 | Nicholia Canyon |
| LIM09 | LP | 20 | 20 | 100 | — | 43.93972 | 112.92534 | Deer Canyon |
| LIM10 | LP | 30 | 30 | 100 | — | 44.24532 | 112.80766 | Buckhorn Canyon |
| Uinta | | | | | | | | |
| WAS03 | LP | 44 | 0 | 0 | 0 | 39.86788 | 111.74625 | Mt. Nebo |
| Wasatch-Cache | | | | | | | | |
| WAS01 | LP | 40 | 0 | 0 | 0 | 40.60006 | 111.59843 | Solitude Ski Area |
| WAS02 | LP | 41 | 0 | 0 | 0 | 40.65176 | 111.59385 | Silver Peak |
| WAS04 | LP | 52 | 0 | 0 | 0 | 40.56368 | 111.65012 | Snowbird Ski Area |
| STA01 | LP | 52 | 0 | 0 | 0 | 40.48520 | 112.62066 | Stansbury Range |
| LIM13 | LP | 4 | 0 | 0 | — | 37.49200 | 111.17500 | Yellow Pine |
| LIM14 | LP | 10 | 0 | 0 | — | 41.77800 | 111.63200 | Logan Cave |
| LIM15 | LP | 5 | 0 | 0 | — | 41.82700 | 111.59500 | Ricks Spring |
| LIM16 | LP | 10 | 0 | 0 | — | 41.93900 | 111.54900 | Beaver Mtn. |
| LIM17 | LP | 30 | 0 | 0 | — | 41.90900 | 111.45200 | Old Limber Trail |